

Nanotechnology in Cancer Imaging

Sanjiv Sam Gambhir, M.D., Ph.D.

Director, Molecular Imaging Center at Stanford School of Medicine

Joe Balintfy: In this part of our series on nanotechnology and cancer, we talk to Dr. Sam Gambhir, professor of radiology and bioengineering at Stanford University about imaging. First, Dr. Gambhir, what are the more common imaging methods used today to detect and treat cancer?

Dr. Sanjiv Sam Gambhir: The more common imaging methods that are used to both detect cancer, stage it, monitor response to therapies, and then also monitor for recurrence are predominately positron emission tomography, or PET scanning; single photon emission computed tomography, or SPECT scanning; and then magnetic resonance imaging, or MRI; as well as computed tomography, or CT scanning. So PET, SPECT, MRI and CT are by far the most dominant players in most cancer, and then ultrasound is also playing an important role.

Balintfy: How effective are these techniques?

Gambhir: They have different accuracies depending on what type of cancer you are studying, where in the body you are looking, whether you are looking at the primary cancer or its metastases. In general, they are quite useful clinically, but we know we need to do better.

The problem is these technologies are still not perfect. So if there's very few cells that have metastasized away from the primary at a distant site, the PET scan might miss them. It might say that there is nothing there when in fact there is something there. So especially micro metastasis, as they are called, smaller amounts of tumor burden, are the hardest things for all these technologies to solve.

Balintfy: Can nanotechnology help?

Gambhir: Yes, so the hope is that, that nanotechnology and nanoparticles coupled with the right imaging instruments, whether they be PET, whether they be MRI, whether they be multimodality imaging instruments like combined MRI PET, all those will benefit from nanotechnologies in the future.

Balintfy: How does imaging with nanotechnology, compare to imaging using molecules? Are there advantages to using nanoparticles Dr. Gambhir?

Gambhir: Yes, so in molecular imaging, molecules are injected into the body that go and home in on other molecules, molecules that might be indicative of cancer. But once they home in on those molecules, they have to produce a large signal that we can detect outside the human body. So nanoparticles are able to sometimes serve as very good amplifiers. They amplify the signal much more so than a small molecule might or even a protein or a biologic might. So one big advantage is the signaling power.

Another advantage is that as we try to use nanoparticles because they have more landscape, they are larger, we can functionalize them with different molecules so they have multiple functions.

A third big advantage that nanoparticles offer is that they end up sometimes being multimodality competent. That is, you can make a nanoparticle so that it produces a signal both for an MRI camera, and for a PET camera, and for a third modality. That multimodality feature of a particle is harder to do when the particle is not a nanoparticle and is a small molecule.

And finally, the fourth big advantage of nanoparticles is that they themselves can help be both a diagnostic and a therapeutic. So if you are going to bother to image a tumor and send a particle in that can go hunt down an abnormal protein in a tumor cell, why not also have the particle be a therapeutic as well, because there is obviously similar goals between diagnosing and therapy or treating. So this whole field of theranostics, the merger of therapeutics and diagnostics, so-called theranostics, has the potential to benefit a lot from nanoparticles that serve both as the diagnostic or imaging agent and as a therapeutic. And that is the one other major advantage nanoparticles have over molecule types for molecular imaging.

Balintfy: What example would you share as a recent nanotechnology breakthrough in cancer imaging?

Gambhir: We have, in development as part of our own nanocenter, particles that are made out of gold that go into the bowel to detect colorectal cancer. But the way the gold helps us to detect the colorectal cancer is that we use a fundamentally new way of imaging called Raman spectroscopy, and the gold acts as an amplifier to produce a very heavy or strong Raman signal from the gold particle after it has latched onto a colorectal cancer. So right now, flat lesions especially might be entirely missed by the endoscopist who might be doing screening for colorectal cancer, but by having the gold nanoparticles light up literally where the cancer, including flat lesions, might be hiding in the bowel, now the hope is that the endoscopist will be able to act on a lesion they would have otherwise missed.

So this strategy, in this case, involves a nanoparticle, one made out of gold. It involves an imaging strategy, which is not MRI, not PET, not SPECT, not CT, not ultrasound. It is called Raman imaging, and really this imaging is only possible with a nanoparticle. That is, without a nanoparticle, Raman imaging is just too insensitive. So there are many examples like this where the nanoparticles are enabling significant signal and actually enabling entirely new kinds of imaging technologies that can work with the human body that previously could not have worked because the nanoparticles were not there to produce the right signals for those imaging technologies.

Balintfy: Can you share some other examples Dr. Gambhir?

Gambhir: Yes, so the other—so the Raman imaging is one. The second I would say is nanoparticles for photoacoustics. In photoacoustic imaging, light goes into the body, red shifted light that can penetrate deeply, that light interacts with a nanoparticle, and the nanoparticle then slightly heats, not enough to cause any damage, but slightly heats. And that heating produces a pressure wave and therefore sound. So light in, sound out. And a nanoparticle can be designed so that it is very good at absorbing the light and very good therefore at producing sound. And the

nanoparticle can be functionalized to go find tumors. Gold, as it turns out, is also a very good material for absorbing light and producing a strong photoacoustic signal. Also carbon-based molecule like nanotubes are very black and dark; they do a good job of absorbing light and therefore heat to produce sound. And several other molecule nanoparticle strategies are on the horizon for this new emerging area of photoacoustic imaging.

And these likely will translate in the clinic with applications of prostate cancer imaging, breast cancer imaging, things where you aren't trying to go too deep, but deep enough where light can go in and sound come back out, letting you get much better spatial resolution, much better sensitivity to detect smaller tumors than what is what is possible with other current imaging technologies.

(THEME MUSIC)

Balintfy: Thanks to Dr. Sam Gambhir at Stanford University. For more information on nanotechnology and cancer, visit the website, nano.cancer.gov. This nanotechnology series will continue next episode when we'll talk more about nanotechnology and diagnostics.

“If you want to use a Christmas tree analogy, they're little ornaments, they're balls, they're little nanoclusters in our case of gold and then we use the gold as a catalyst.”

But remember, as mentioned at the beginning of the program, NIH Research Radio is taking a break: our next edition, episode 125 scheduled for Friday, December 31 won't be available until Friday, January 14.

For now that's it for this episode of NIH Research Radio. Please join us again on Friday, January 14 when our next edition will be available. As usual, if you have any questions or comments about this program, or have story suggestions for a future episode, please let me know. Best to reach me by email—my address is jb998w@nih.gov. I'm your host, Joe Balintfy. Thanks for listening.